



Geothermal 202

Where's the Geyser in
Illinois ???

Underground, Low-
Temperature Energy

Geothermal 202
FOR
The Illinois Green Economy Network
The Green Institute
Heartland Community College
October 28, 2011

Presenter

L. R. Hoover, P.E.

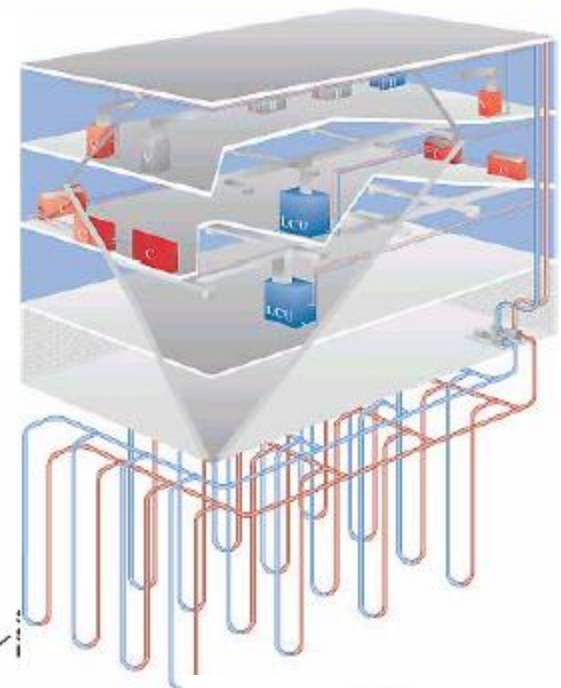
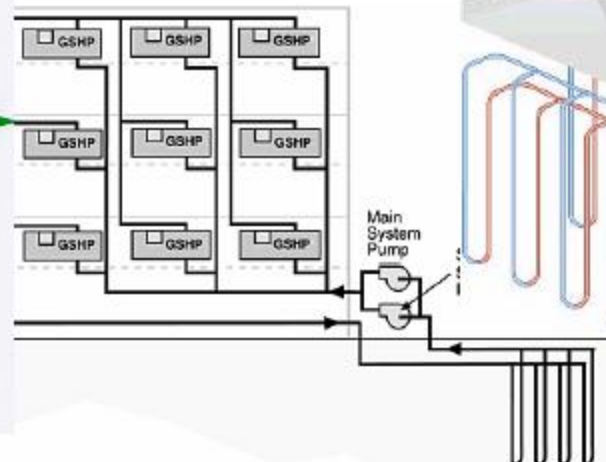
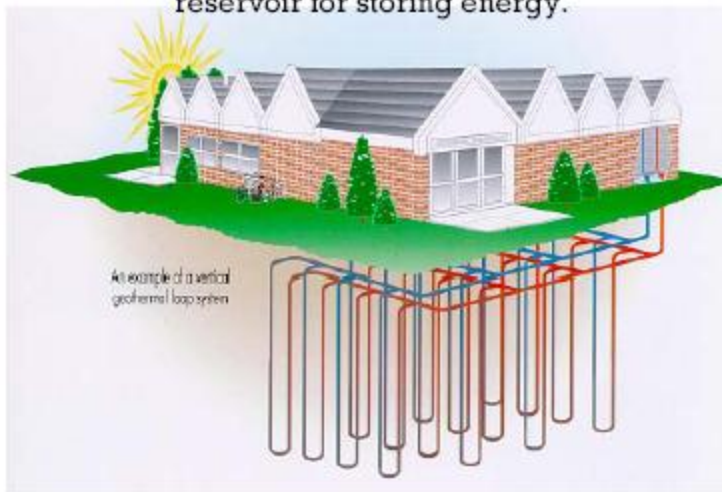
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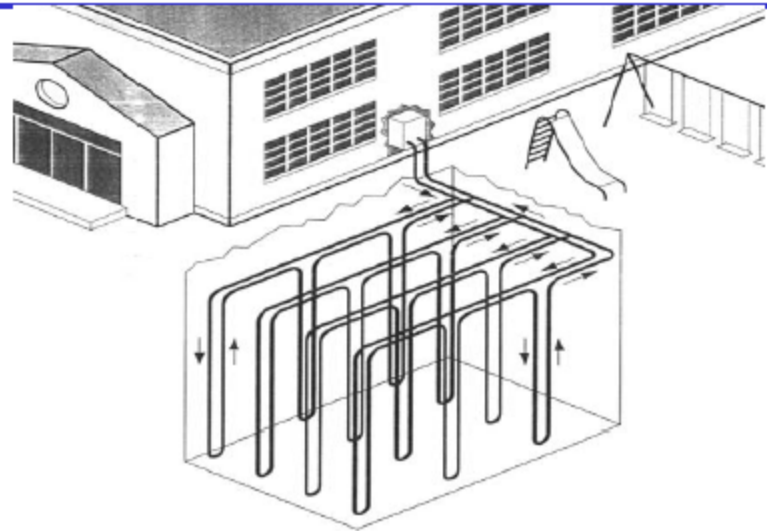
What's GeoExchange?

A GeoExchange system (or also referred to as a geothermal heat pump system, or ground source heat pump) consists of one or more water-source heat pump units inside the building, which are connected by a common water distribution loop to an earth-coupled heat exchanger (or "ground loop") outside the building. This systems exchanges heat between the building and the earth, and vise versa. The Earth acts as a reservoir for storing energy.



What's Outside?

- GeoExchange Loop-field (underground energy storage)
- Each loop 100-400 feet down
- All loops connected in a manifold
- Manifold 4-5 feet below ground
- Land over field can be used for other purposes.
- Many options and variation of the GeoExchange system

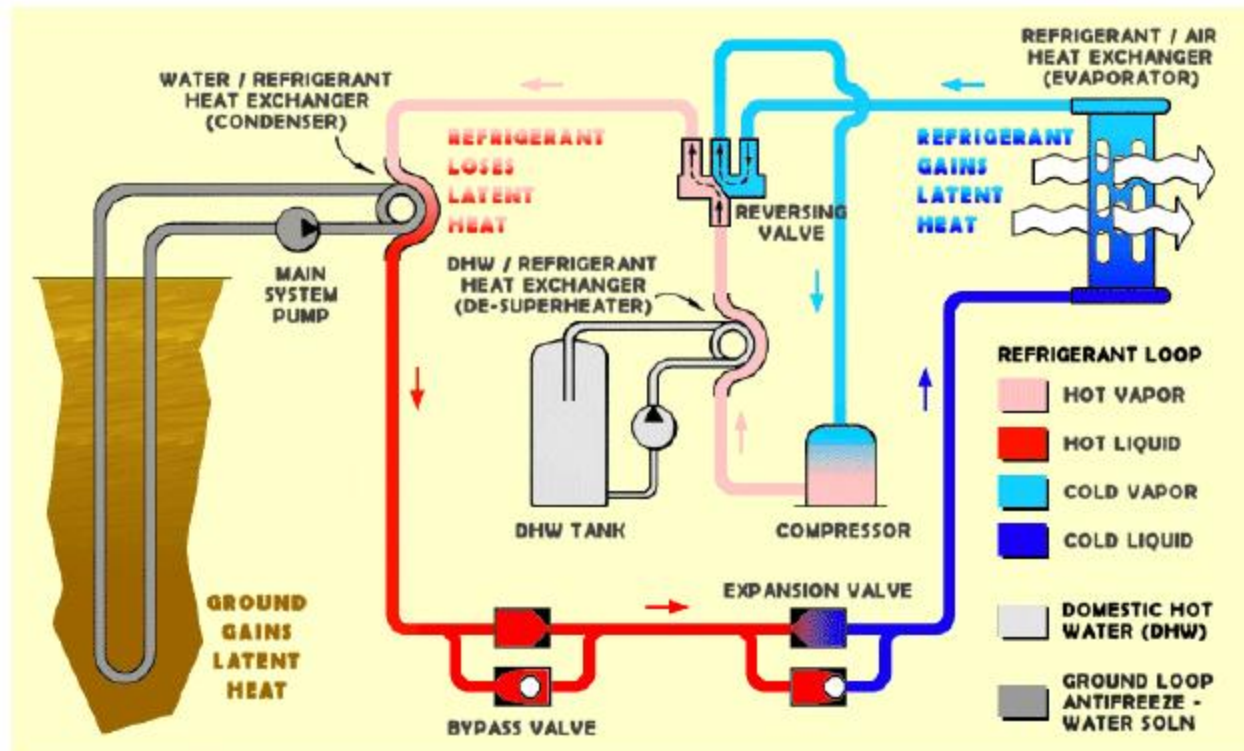




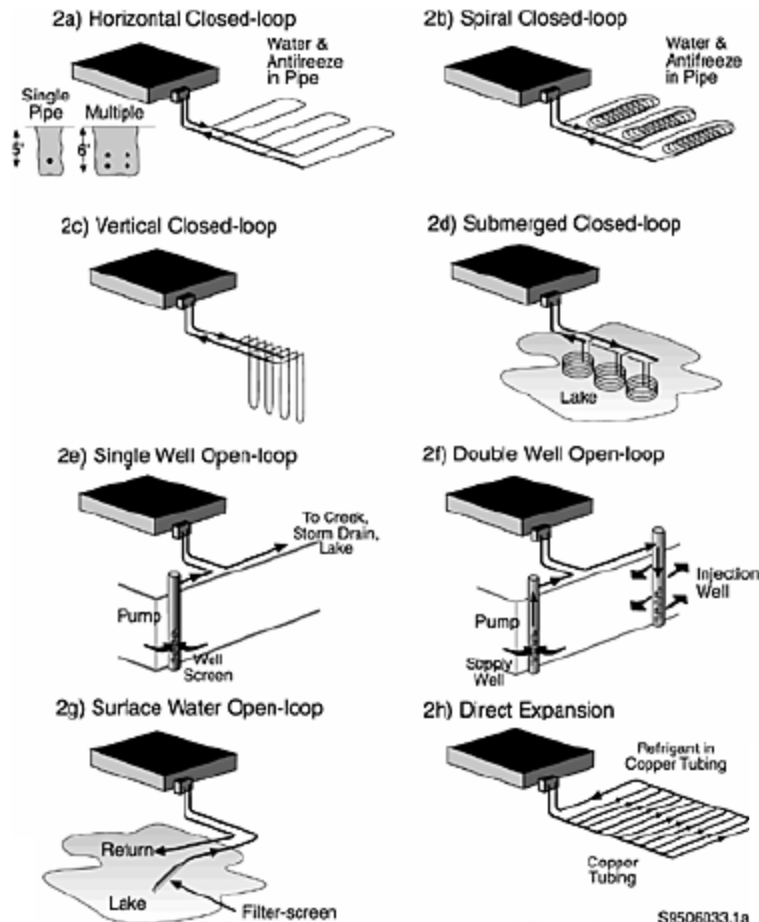


How does a heat pump work?

Cooling Cycle



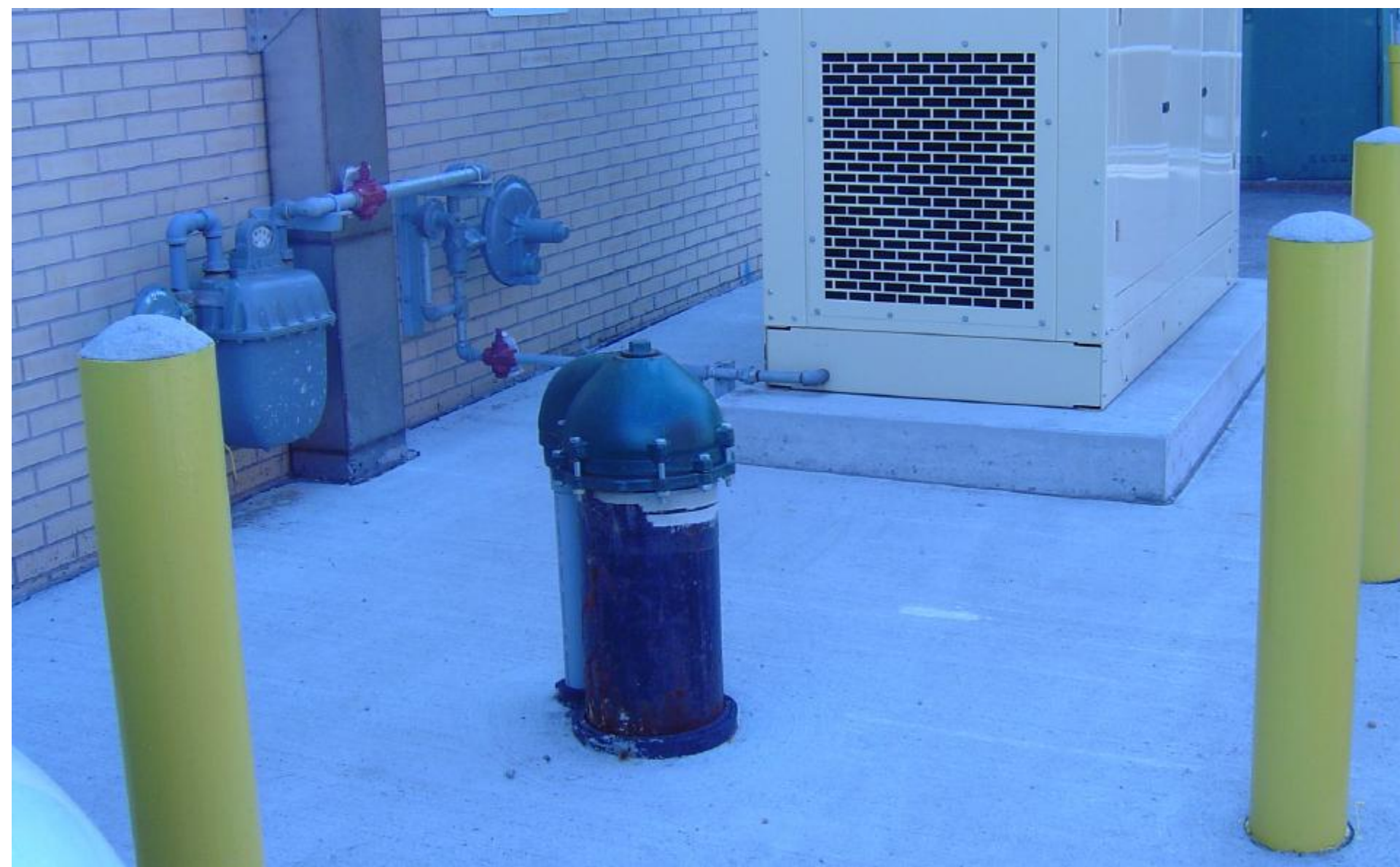
GeoExchange System Types



S9506033.1a



Urban Well Head



City Adm. Bldg & Jail Dubuque, IA



Typical Well Head in Town



Prescott School, Downtown DB





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NICHOLAS CONSERVATORY & GARDENS

Bobcat

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Dubuque County Courthouse



Loras College, Dubuque



Alliant Energy Offices, Mid-Town

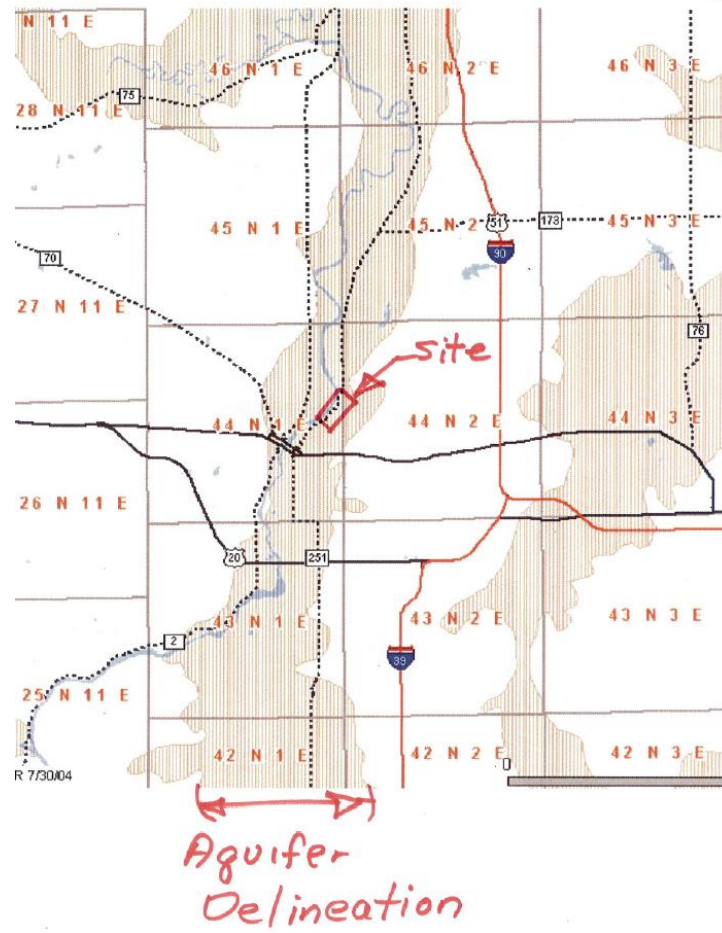


Grand Harbor Conference Center





MAR 5 2007



INTERACTION OF GROUND WATER AND STREAMS

Streams interact with ground water in all types of landscapes (see Box B). The interaction takes place in three basic ways: streams gain water from inflow of ground water through the streambed (gaining stream, Figure 8A), they lose water to ground water by outflow through the streambed (losing stream, Figure 9A), or they do both, gaining in some reaches and losing in other reaches. For ground water to discharge into a stream channel, the altitude of the water table in the vicinity of the stream must be higher than the altitude of the stream-water surface. Conversely, for surface water to seep to ground water, the altitude of the water table in the vicinity of the stream must be lower than the altitude of the stream-water surface. Contours of water-table elevation indicate gaining streams by pointing in an upstream direction (Figure 8B), and they indicate losing streams by pointing in a downstream direction (Figure 9B) in the immediate vicinity of the stream.

(Box B)

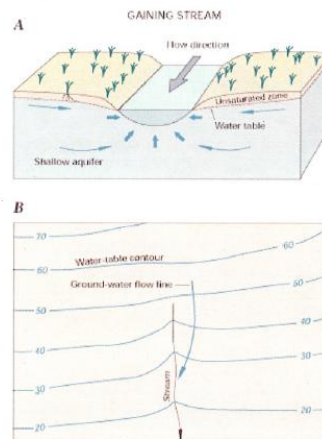


Figure 8. Gaining streams receive water from the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the upstream direction where they cross the stream (B).

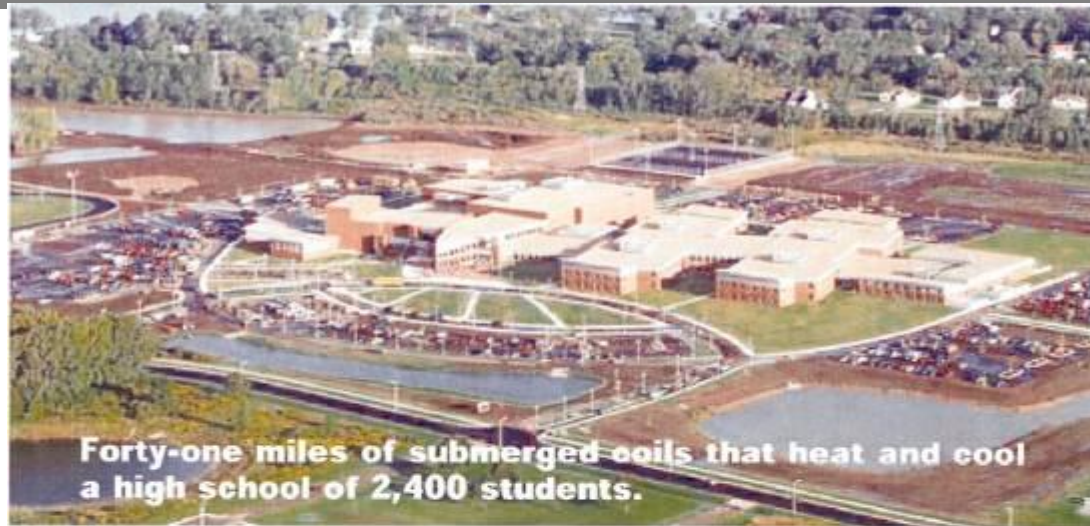
Connect Header on-site



“Slinky” Pond Loop



Fond-du Lac High School



In the fall of 2001, Fond du Lac High School opened its doors to students and began operation of the largest geothermal pond system in the United States. Using energy from the earth, geothermal technology provides a reliable and economical heating and cooling alternative for schools and other large commercial institutions.

As a result of its leadership, Fond du Lac High School enjoys \$290,000 per year in avoided operating costs and is providing unparalleled comfort and reliability to its occupants. This brochure will take you on a tour of this innovative and environmentally friendly heating and cooling technology.

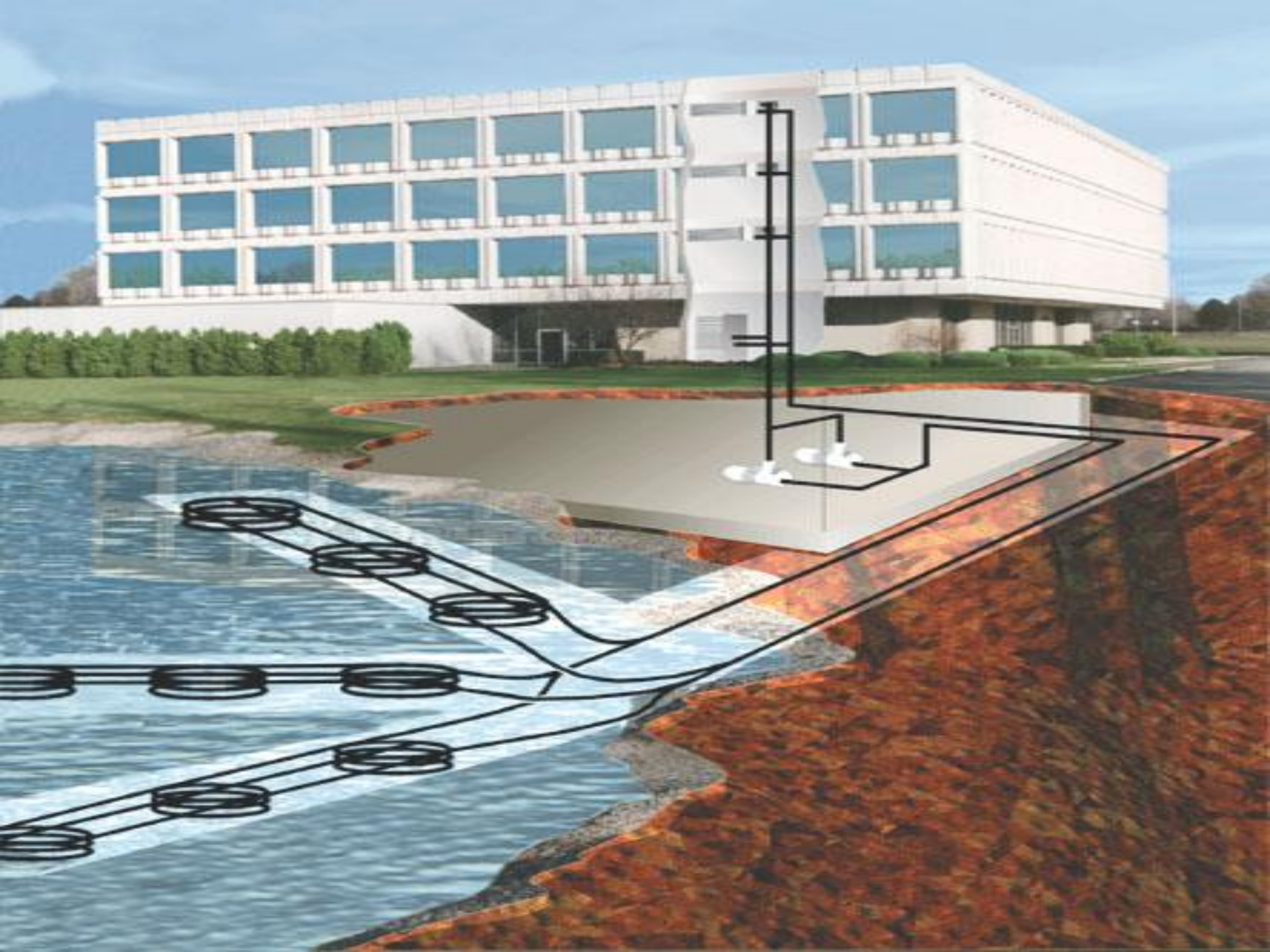
THE SCHOOL

ponds, the geothermal system heats and cools the building using well-established, reliable heat pump technology.

Science teachers originally brought the technology to the attention of Building and Grounds Supervisor Jim Gescheidle and the building contractors. In response, they decided to investigate the alternatives by visiting Alliant Energy's GeoThermal Van, which was visiting nearby Goodrich High School. This led to trips to Iowa and Indiana to visit geothermal systems that had been installed in commercial facilities.

"We came back very enthused about what geothermal technology could do for us," says Gescheidle. "Then we set







Living Waters Church

2-10 Ton slinky loops



The image shows a large-scale construction project for a church. The ground is covered with numerous rows of black, coiled slinky loops, which are used for radiant heating. Two men are standing in the middle of the site, holding a sign. The background features a steep, rocky embankment and some trees.

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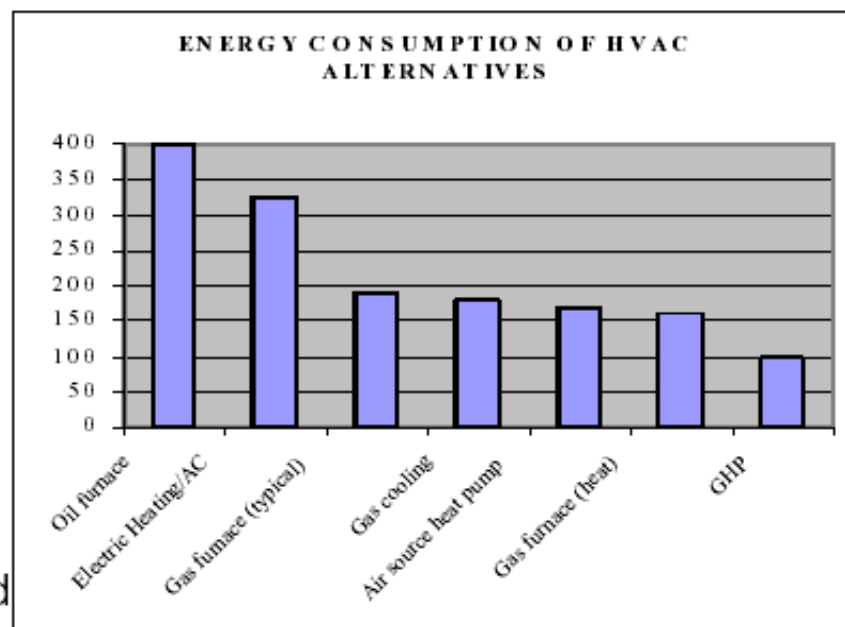
What you won't find

- Gas or Electric Boilers
- Cooling tower or condenser
- Chillers
- Complex controls
- Roof Top Penetrations
- Expensive repairs/maintenance contract



Energy Benefits

- **Reduced Energy Consumption**
 - 80% reduction in heating energy use
 - Up to 50% reduction in cooling energy use
 - Reduces peak electrical load
- **Recycles/re-uses energy**
 - “Free” heat for water heating
 - Recycle heat within a building
 - Store excess heat underground for use during the winter.
 - No wasteful re-heating



ENERGY COST COMPARISON

FOSSIL FUELS AND GEOTHERMAL

| Fuel Type | Units | \$ / Unit | Efficiency | Cost per 1,000,000 BTUs |
|------------------------|------------------|-----------|------------|----------------------------|
| Natural Gas | 102000 BTU/Therm | 1.00 | 0.92 | \$10.66 |
| | | 1.60 | 0.92 | \$17.05 |
| | | 1.80 | 0.92 | \$19.18 |
| Fuel Oil | 131000 BTU/Gal | 3.40 | 0.78 | \$33.27 |
| LP Propane | 104000 BTU/Gal | 1.70 | 0.88 | \$18.58 |
| | | 2.00 | 0.88 | \$21.85 |
| Electric Resistance | 3413 BTU/KWH | 0.06 | 1.00 | \$17.58 |
| | | 0.10 | 1.00 | \$28.13 |
| | | 0.12 | 1.00 | \$33.75 |
| Geothermal | 3413 BTU/KWH | 0.08 | 3.6 | \$ 6.26 |
| | | 0.10 | 3.6 | \$ 7.72 |
| | | 0.12 | 3.7 | \$ 9.01 |



HVAC SYSTEM & CARBON FOOTPRINT COMPARISON

| HVAC System & Water Heater | Annual Cost | Carbon Footprint Metric Tons |
|---|-------------|------------------------------|
| 80% NG with Pilot, Comb & 12 SEER AC; NG WH | \$2,334 | 11.07 |
| 95% NG HIS, Condensing & 14 SEER AC; NG WH | \$1,922 | 10.07 |
| 80% NG with Pilot, Comb & 12 SEER AC; NG WH (Tighter Building Envelope) | \$2,099 | 9.6 |
| 80% LP with Pilot, Comb Blwr & 12 SEER AC; Prop WH | \$3,759 | 13.98 |
| 80% LP with Pilot, Comb Blwr & 12 SEER AC; Prop WH (Tighter Building Envelope) | \$3,346 | 12.31 |
| 95% LP with Pilot, Comb Blwr & 12 SEER AC; Prop WH | \$3,094 | 11.77 |
| 14 SEER AHP with 80% Prop; Electric WH | \$2,162 | 13.61 |
| 14 SEER AHP with 80% NG; Electric WH | \$1,824 | 13.22 |
| 14 SEER AHP with Electric Resistance, Electric WH | \$1,896 | 16.01 |
| 3.5 COP Geothermal, Electric WH | \$ 956 | 8.83 |
| 4.0 COP Geothermal; Electric WH | \$ 816 | 7.42 |



Health and Safety Benefits

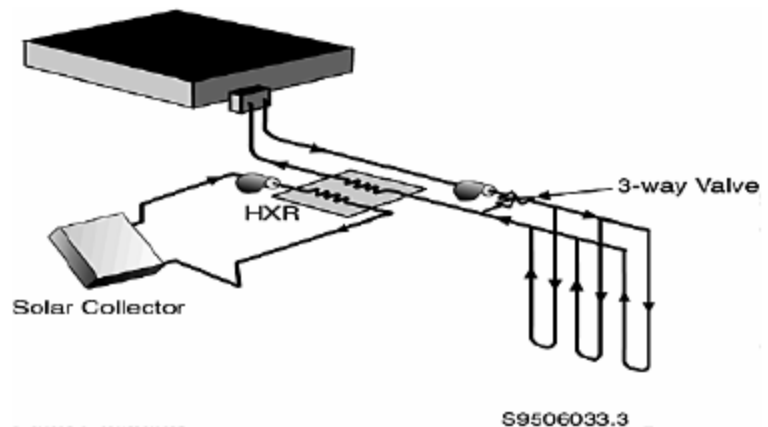
- No exhaust flue concerns or risks
- Vandalism and safety issues of outside equipment eliminated
- No rooftop equipment maintenance safety issues.
- Possibly yield lower insurance premiums for liability and equipment coverage.



Environmental Benefits

- **Utilizes Renewable Energy Resource**

- Recovers solar energy stored in the earth (2/3 of building heat can be from solar)
- Can enable you to achieve renewable energy points in LEED rating system (20% or more total on-site renewable energy)
- Can incorporate thermal solar panels into the system, and utilize earth for additional thermal heat storage.



- **Cleaner Air**

- EPA Endorsed
- No on-site emissions
- Less overall emissions (power plant vs. boiler)



People Benefits

- Improved Comfort and Control
 - No switch over - heat or cool at a “flip of a switch”
 - Multiple zones, each have individual room controls
 - Reduced hot/cold complaints
 - Improved productivity, work/learning environment
- Quiet
- Improved Indoor Air Quality
 - Dedicated ventilation air system



Benefits Summary

- Energy benefits -- greater efficiency and lower energy costs
- Equipment benefits -- longer service life and lower maintenance costs
- Building design benefits -- space savings and lower construction costs
- Health and safety benefits -- reduced risk and lower insurance costs
- Environmental benefits -- least impact of all heating and cooling alternatives
- People benefits -- improved comfort means improved productivity, and less comfort complaints
- **Save Green**, while \$aving Green



For what type of project is Geoexchange most desirable?

- Need for the benefits just described
- Require both heat and cooling
- Desire to have lowest life-cycle cost
- Need for individual control of heating and cooling



Most Common Applications

- Residential
- Schools
- Assisted Living
- Office
- Health Care



...GeoExchange has been applied in all types of projects...everywhere



Equipment Benefits

- **Less Maintenance Requirements**
 - Simpler Controls (KISS)
 - No maintenance intensive cooling towers, boilers, chillers
 - Equipment sheltered from weather-related damage and vandalism.
 - Eliminates conventional roof top equipment. Less potential for leaks and on-going maintenance, and better roof warranties

- **Long Equipment Life**
 - Underground piping carries warranties of 25 to 50 years
 - Heat Pumps typically last over 20 years
- **Easier Maintenance**
 - Required level of maintenance, and skill level of maintenance person is less costly.
 - Most or all maintenance can be done “in-house”
 - Repairs are less expensive

Mean and Median Total Maintenance Costs

Source: Survey and Analysis of Maintenance and Service Costs in Commercial Building Geothermal Systems RP-024 6/97

| System | Mean Cost (\$/100 sq. foot) | Median Cost (\$/100 sq. foot) | Max Cost (\$/100 sq. foot) |
|---|-----------------------------|-------------------------------|----------------------------|
| Ground Source Heat Pump (Geothermal) (In House Labor) | \$9.30 | \$7.35 | \$31.35 |
| Ground Source Heat Pump (Contracted labor) | \$10.95 | \$8.37 | \$38.08 |
| Water Source Heat Pump (Boiler/tower system) (Not geothermal system) | \$21.80 | \$20.80 | \$75 |
| Reciprocating Chiller | \$28.80 | \$23.50 | \$140.30 |
| Absorption Chiller | \$52.50 | \$48.40 | \$136.20 |

GeoExchange 101:
April 17/18, 2007

GEOEXCHANGE
GEOTHERMAL HEAT PUMP CONSORTIUM

dceo
ILLINOIS DEPARTMENT OF COMMERCE AND ECONOMIC OPPORTUNITY







LEED® and Geoexchange

What is LEED®?

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.

GeoExchange directly impacts LEED by reducing energy consumption, but it has many indirect environmental design advantages as well

[Geoexchange](#)



Federal Tax Incentives and Potential Funding Sources

- Energy Tax Bill and Energy Stimulus Bill
 - The Energy Policy Act of 2005 provides a variety of tax incentives for homeowners, businesses, and manufacturers for purchase of energy efficient equipment and buildings, which will be available after January 1, 2006 and before December 31, 2007.
 - *Energy-efficient Commercial building tax deduction.* \$1.80/SF for reducing energy use 50% from ASHRAE 90.1-2001.
 - www.sedac.org/ www.dsireusa.org (links to good info)
 - Illinois DCEO manages a number of stimulus EE incentive programs.
- Utilities
 - Cooperatives
 - Ameren (Act on Energy)
 - Municipal Utilities



Federal Tax Incentives and Potential Funding Sources, Cont'd

- **USDA Grant Program**
 - **Rural Energy for America (REAP) formerly Section 9006**
 - **New for 2006, the program offers both grants and guaranteed loans for eligible projects.**
In addition, projects with total eligible costs under \$200,000 can apply under a Simplified Application Process designed to streamline the application process for small projects
 - **Project must be located in a recognized rural area**
 - **Visit <http://www.rurdev.usda.gov/rd/energy/>**

Illinois Clean Energy Community Foundation

- **Will pay 1/3 of the incremental cost**
- **Available for not-for-profit agencies and institutions only**
- **Must follow grant application guidelines**
- **Visit <http://www.illinoiscleanenergy.org/>**



Open Loop Energy Sources

- Ground Water from Wells
- Sewage treatment Plant discharge
- Waste water from Dairy Processing
- Other industrial processes
- Plastic Injection molding (cooling water used as a heat source)

Lon's Inaccurate Cost Estimates

100-ton example

Geo Equipment @ \$2500-3000/ton = \$250-300

Vertical GHEX @ \$1800-2200/ ton = \$180-220

Horizontal GHEX @ \$1000-1100 = \$100-110

Pond Loop @ \$600 – 800 / ton = \$ 60-80

Open Loop Well (150 GPM) \$25,000-\$50,000

Controls, duct work, power supply, Design fees,

Recharge well, Permits

Resources for GeoExchange Designers

- *Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institutional Buildings*, Kavanaugh and Rafferty (ASHRAE, 1997)
- *Commercial/Institutional Ground Source Heat Pump Engineering Manual*. Caneta Research. (ASHRAE, 1995)
- *Closed Loop/Ground Source Heat Pump Systems: Installation Guide* (IGSHPA)
- *Learning from Experiences with Commercial/Institutional Heat Pump Systems in Cold Climates*, Caneta Research. (CADDET, 2000)
- Chapter 32: Geothermal Energy. 2003 HVAC Applications Handbook (ASHRAE)
- ASHRAE Library: Extensive number of technical abstracts for purchase.
- Generic geothermal specifications (just google geothermal heat pump specifications)
- Illinois Geological survey water well data base
<http://www.isgs.uiuc.edu/wwdb/index.htm>
- *Generic specifications* <http://www.ornl.gov/~webworks/cpr/v823/rpt/107119.pdf>
- *Geothermal Design Manual (211 page) (Aug-2002)*
<http://www.ci.nyc.ny.us/html/ddc/html/ddcgreen/geotherm.html>

GeoExchange 101:
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Resources cont.

- General Information
 - <http://www.geo4va.vt.edu/indexGeo4VA.htm> (Excellent overview)
 - <http://geoheat.oit.edu/> (Geo-heat center)
 - <http://www.eere.energy.gov/femp/financing/espc/ghpresources.html> (bunch of govt. information)
 - <http://www.alliantenergygeothermal.com/> (excellent overview)
 - http://www.pnl.gov/fta/2_ground.htm#case (federal technology alert)
 - <http://www.geokiss.com/> (GHP design info)
 - http://www.advancedbuildings.org/_frames/fr_t_heat_ground_heat_pumps.htm (Advanced Buildings Technology and Practices)
- Trade Associations
 - www.ASHRAE.org (visit library and search for all references to heat pumps)
 - TC 6.8, Geothermal Energy Utilization
 - TC 7.6 Unity and Room conditioners and Heat Pumps
 - TC 9.4 Applied Heat Pump/Heat Recovery Systems
 - <http://www.ghpc.org/home.htm> (Geothermal Heat Pump Consortium)
 - <http://www.heatpumpcentre.org/> (IEA Heat Pump Centre)
 - <http://www.igshpa.okstate.edu/> (International Ground Source Heat Pump Association)

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